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AND
CEMENT MANUFACTURE

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Special Cements.

By Dr. C. R. PLATZMANN.

As Portland cement displaced Roman cement in the nineteenth century it was assumed that the production of hydraulic binding materials could be improved no further. This assumption has since been proved erroneous. A large number of cements having special qualities have come on to the market, the slag cement industry has been developed, and finally there has been the discovery of aluminous cement. This article describes briefly the production and characteristics of existing special cements.

Rapid-Hardening Portland Cement.

This is known under other names such as " high-strength cement," " special cement," and " early hardening cement." It is a true Portland cement characterised by an early development of strength, so that laboratory tests at one or two days are frequently as high as the tests of ordinary Portland cement at 28 days, and it is usually claimed that the strength of concrete made with this cement is as high at four days as that of ordinary cement at 28 days.

White Portland Cement.

If marked as white " Portland " cement, this is only distinguishable from ordinary Portland cement in its colour, which is due to the content of iron oxide being not more than 0.5 per cent.

Roman Cement.

Roman cement is the name given by Parker in 1796 to a cement made by calcining (to a temperature below clinkering point), and subsequently grinding calcareous nodules which are to be found on the British sea coast at various places. The percentage of lime in Roman cement is considerably lower than in ordinary cement, and consequently it does not attain any great strength. Although it was superseded by Portland cement many years ago, Roman cement

is still marketed in very small quantities, its chief attraction being its quick setting property which makes it suitable for pointing marine structures between tides.

Selenitic Cement, or Scott's Cement.

This is made by grinding hydraulic lime with a proportion of gypsum up to 10 per cent. The addition of gypsum improves the strength of the lime.

Natural Cement, or Rossendale Cement.

This is made from calcareous marl or argillaceous limestone containing from 65 to 85 per cent. of calcium carbonate; in some cases magnesia displaces some of the lime. There is no grinding or "washing" of the raw materials as occurs in the production of Portland cement, but the natural rock is sent direct to the kilns for burning. "Seasoning" of the clinker before grinding is usually practised to improve the soundness of the cement. Cements made in this way are naturally inferior to Portland cements. Natural cements are not made in Great Britain, but, although in process of being displaced by Portland cement, they are still marketed in America and certain parts of Europe.

Grappier Cement.

Grappier cement is unknown in Great Britain, being made principally in France. It is the clinkered product which forms part of the output of kilns burning strongly hydraulic lime and is therefore akin to natural cement.

Ore Cement.

The inventors of ore cement are Michaelis and the Krupp-Gesellschaft. According to German patent No. 143604, a cement is prepared in which the percentages of alumina and iron content are interchanged, with the object of rendering the cement less sensitive to the action of sulphate solutions, and therefore to protect it against the action of sea water. The low content of alumina avoids the formation of calcium sulpho-aluminate which tends to cause unsoundness. On account of its high iron content the cement has a brown to dark brown colour.

Limestone, marl, and iron ore are used as raw materials. The specific gravity of ore cement can be as high as 3.3. It is a pure Portland cement, since it complies to the fullest extent with the definition of Portland cement. In the manufacture, which is normal throughout, one molecule of iron oxide is taken for three molecules calcium carbonate, next one molecule alumina to one molecule calcium carbonate, and one molecule silica to two molecules calcium carbonate.

Ore cement is manufactured at the Hemmoor Cement Works near the mouth of the Elbe. The results of analyses are as follow:

	Hemmoor. Per cent.	After Schoch. Per cent.
Iron oxide	7.73	8.03
Alumina	1.35	3.47
Silica	24.61	20.81
Lime	61.91	65.06

Iron Portland and Blastfurnace Cements.

A particular class of special cements is represented by what are best described as " mixed cements," except that this implies a criticism of their quality. Mixed cements contain more or less Portland cement clinker with which latent hydraulic materials are ground. The " hütten " cements are the most significant in this connection. Iron Portland and blastfurnace cements belong to this class.

The hydraulic properties of basic blastfurnace slags were known in the last century, but they were valued at first only for the production of slag cement generally consisting of 70 to 85 per cent. of blastfurnace slag and 15 to 30 per cent. of dry slaked lime. The next step, which led to the present " hütten " cement industry, was the production of Portland cement in the usual way from limestone and blastfurnace slag. Portland cement clinker made from limestone and blastfurnace slag was ground intimately with blastfurnace slag; in this way " iron Portland cement " and " blastfurnace cement " are obtained.

Iron Portland cement is a mixture of 70 per cent. Portland cement clinker with 30 per cent. slag. It should contain for every one part by weight of soluble silica and one part alumina at least one part of lime plus magnesia.

With regard to blastfurnace cements, which may contain between 15 and 69 per cent. of Portland cement clinker, but mostly contain 30 parts cement and 70 parts slag, it has been found that only basic blastfurnace slag which has been granulated by quick cooling may be ground in.

The following formula is applicable only to slag obtained from an iron blastfurnace process:

$$\frac{CaO + MgO + \frac{1}{3}Al_2O_3}{SiO_2 + \frac{2}{3}Al_2O_3} > 1.$$

Further, the slag should not contain more than 5 per cent. MnO.

The composition of usable slags varies within the following limits: silica, 29.60 to 34.20 per cent.; alumina, 9.84 to 15.50 per cent.; ferrous and ferric oxide, 0.35 to 0.27 per cent.; manganous oxide, 0.24 to 0.51 per cent.; lime, 41.45 to 46.27 per cent.; magnesia, 1.98 to 4.46 per cent.; calcium sulphate, 0.00 to 1.07 per cent.; calcium sulphide, 3.60 to 6.86 per cent.

If blastfurnace slag is allowed to cool slowly a crystalline flour is obtained which is not suitable for grinding in but is used as a material for the manufacture of Portland cement. The added slag with latent hydraulic characteristics is distinguished by having been rapidly cooled either in water or by air-granulation by which it is enriched with glassy constituents.

The introduction of iron Portland and blastfurnace cements was due chiefly to German chemists such as Stein, H. Passow, R. Grün, and A. Guttmann. Hence most of the works of this type are to be found in Germany, and their total capacity is at least one million tons. The methods of manufacturing the

requisite amount of Portland cement are identical with those of the Portland cement industry. The method of the I.G. Farbeindustrie A.G. merits special mention ; in this a Portland cement is made from gypsum and blastfurnace slag at the same time as sulphurous acid which is later converted to sulphuric acid. The cement is then converted into blastfurnace cement by grinding with slag.

In the last few years early hardening " hütten " cements have been produced ; these generally contain 40 per cent. of Portland cement clinker ; the high early strength iron Portland cements, however, contain the usual 70 per cent. of clinker. On account of the low lime content of " hütten " cements, it is claimed that they occasionally have a better resistance to sulphate solutions. Other countries, including England, France, Italy, Russia, Japan and America, have also erected " hütten " cement works.

The chemical composition of " hütten " cements is distinguished from that of Portland cement by the lower content of lime. The following analyses serve as examples :

	Blastfurnace Cement. Per cent.	Iron Portland Cement. Per cent.
Silica	28 to 36	24 to 32
Alumina..	8 to 20	5 to 12
Ferrous oxide	1 to 5	1 to 3
Lime	45 to 55	55 to 63
Magnesia	1 to 8	1 to 4

Pozzolanic Cements.

The use of pozzolanas in a ground state was known by the Romans, since they employed them mixed with lime for structures which partly exist to-day ; for example, the aqueduct from the Eifel to Cologne. The Romans used pozzolanas, named after the district Puzzuoli, in Italy and trass in the crushed and ground state in the Rhineland. Both materials are noted for their high content of silica soluble in hydrochloric acid, and it is this silica which, with lime, is converted to calcium silicates and thus causes hardening under water. Nowadays this type of material is only used as an admixture when particularly dense concrete is required, and especially for concrete in sea water. The conversion of the calcium hydrate liberated in setting and hardening to the insoluble and resistant silicates increases the resistance to sulphates. However, we are not limited to this naturally occurring material, for industrial waste products such as blastfurnace slag have been used for the same purpose. The so-called Si-stoff is also well-known in this connection. This is a waste product from clay after extraction with sulphuric acid in the manufacture of alumina, and is noted for its high content of soluble silica. The following analyses give an idea of the compositions of these substances :

	Trass. Per cent.	Pozzolanic earth. Per cent.	Santorin earth. Per cent.	Si-stoff. Per cent.
Water of hydration ..	3 to 12	up to 12	4.19	0.47
Silica	49 to 59	52 to 60	66.12	69.34
Alumina	10 to 19	9 to 21	15.01	16.85
Iron oxide ..	4 to 12	5 to 22	4.44	
Lime	1 to 8	2 to 10	2.84	0.60
Magnesia	1 to 7	up to 2	1.06	trace
Alkalis	3 to 10	3 to 16	7.61	—
Sulphuric anhydride	—	—	—	3.98

Besides combining with lime these materials are capable of making a dense mass, especially if they are low in fine constituents, generally by increasing the elasticity. A frequent disadvantage is the delayed early strength; the final strength, however, is good.

In Italy, and lately in Germany, Portland cement clinker ground mechanically with pozzolana has been put on the market. The proportion of pozzolanic material (trass) varies generally between 30 and 50 per cent. On account of the intimate mixing and grinding the distribution is more uniform and the effect is greater. The addition of more than 30 per cent. of trass generally lowers the strength somewhat without adversely affecting any of the other advantages.

Soliditit Cements.

The so-called "Soliditit" cements also belong to this group of specially prepared cements. These are Portland cements ground with calcined granite, basalt, or andesite. The object of calcining these natural rocks is to raise their content of soluble silica. In Japan, according to the Japanese patent No. 80692, a so-called "neo-soliditit" cement has been developed which differs from the former in that besides grinding with calcined natural rocks a natural or artificial silicic acid-bearing substance such as kieselguhr, pozzolana, etc., is used also. The composition of a "neo-soliditit" cement of this type is: Portland cement, 70 to 75 per cent.; calcined granite, basalt, or andesite, 10 to 20 per cent.; kieselguhr or pozzolana, 10 to 20 per cent. Better strengths have been given by neo-soliditit cements, as the following tables show:

TENSILE STRENGTH (1 : 3 MIX) IN KG. PER SQ. CM.

	Storage Period, Days.			
	3	7	28	28 (Comb. Storage).
Soliditit	20.6	26.5	31.3	35.9
Neo-soliditit	30.3	35.0	40.9	51.3

COMPRESSIVE STRENGTH (1 : 3 MIX) IN KG. PER SQ. CM.

	Storage Period, Days.			
	3	7	28	28 (Comb. Storage).
Soliditit	174	270	420	482
Neo-soliditit	384	481	630	689

Spent Württemberg oil shale has occasionally been used for the preparation of the so-called " Portlandiurament."

Aluminous Cements.

The high capacity of the calcium aluminates for hardening was known in the middle of the last century, when the German chemist Winkler and the French chemist Frémy obtained them experimentally, and the discovery was later confirmed by Michaelis. The knowledge of the hydraulic properties of the calcium aluminates then seemed to have been lost, and at the beginning of this century it was re-established by Fr. Killig and O. Schott that the calcium aluminates possess an exceptional capacity for hardening. Spackman in America has also investigated the calcium aluminates. It remained, however, for the French to use this scientific work in practice, as only they had bauxite deposits of sufficient purity at their disposal. Bied was responsible for their manufacture during the war. Originally aluminous cements were called " melted cements " (ciment fondu), because during their preparation the raw materials were heated to melting point instead of to sintering point, as is usual in the manufacture of Portland cement. The preparation of the raw material, however, was carried out in the same way. The melting was done either in an electric furnace or in a shaft kiln surrounded by a water jacket for cooling purposes. This latter method resembles in many ways the blastfurnace process for iron with its associated slag. The finished aluminous cement leaves the furnace in a glowing liquid stream and can be ground as soon as it has cooled sufficiently.

Aluminous cements differ from Portland cements by the very high strength they reach in a few hours, by the large amount of heat evolved on setting and hardening (temperature rises of as much as 100 deg. C. have been measured), and by their resistance to sulphates on account of the lime content which is too low to allow of the formation of calcium sulphoaluminate. Aluminous cement works were erected later in other countries, including Hungary, America, England, Italy, and Germany. Most countries, however, import French bauxite or material from Istria. The cost of aluminous cement is, therefore, comparatively high.

The composition of aluminous cement prepared from bauxite and limestone varies between the following limits: Alumina, 35 to 45 per cent.; lime, 29 to 45 per cent.; silica, 8 to 12 per cent.; iron oxide, 6 to 12 per cent.

An investigation of the mechanical properties of an aluminous cement carried out lately at the Stuttgart Technical High School gave the following results: (*a*) Density: The weight of one litre of cement was 0.936 kg. when loosely packed and 1.685 kg. when shaken down. (*b*) Fineness: 4.3 per cent. residue

on the 4900-mesh sieve. (*c*) Setting time: commencement of stiffening, 4 hours; setting time, 13½ hours. (*d*) Soundness: No cracks around the edges or crumbling after 28 days. (*e*) Strength tests on a mixture of 1 part by weight of aluminous cement, 3 parts by weight of standard sand, and 8 per cent. of water gave the following results:

Age.	Storage.	Tensile Strength.	Compressive Strength.
Hours		Kg. per sq. cm.	Kg. per sq. cm.
24	12 hours moist air .. .. / 12 ,, under water ..	27.9	675
48	12 ,, moist air .. .. / 36 ,, under water ..	31.7	728
72	12 ,, moist air .. .. / 60 ,, under water ..	32.2	776
Days 7	12 ,, moist air .. .. / 6½ days under water ..	32.7	849
28	12 hours moist air .. .. / 27½ days under water ..	34.0	955
28	12 hours moist air .. .. / 6½ days under water .. / 21 days in air	52.3	1,054

There are certain transition products between Portland cement and aluminous cement. R. Grün, for instance, has described a lime-aluminous cement consisting of 15 per cent. silica, 50 per cent. lime, 28 per cent. alumina, and 2 per cent. ferrous oxide. The so-called Kühl cement, on the other hand, has one part of alumina replaced by iron oxide compounds.

"Sorel cements" and "Keene's cement" are not relevant to this discussion, because the cause of their hardening is different. The term "cement" should be reserved only for hydraulic binding materials with a lime basis.

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A United States Experimental Cement Plant.

RESEARCH on a comprehensive scale into problems of manufacturing cement and other materials requiring calcination has been made possible at the engineering materials laboratory of the University of California by the installation of a complete dual-kiln unit and a three-stage continuous grinding mill. The new equipment, which is described in *Engineering News Record* by Mr. J. W. Kelly, provides for the study of cement problems from the raw materials to the final product, particularly with regard to the effects of heat treatment of clinker

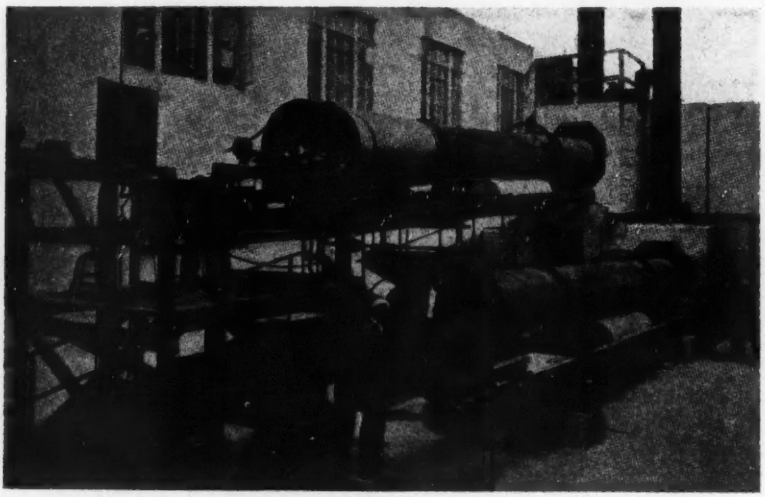

Fig. 1.

in controlled atmospheres. Problems in the manufacture of lightweight aggregates are also under investigation, and a study of limes is contemplated.

The Kilns.

The kilns are 30 in. in outside diameter by 30 ft. long, and have a normal capacity of 60 to 150 lb. of clinker per hour. They are operated under automatic control and are equipped throughout with facilities for observing operating conditions. The primary kiln used for burning the clinker is fundamentally similar to a commercial cement kiln. Clinker from this unit may be discharged into stationary coolers for rapid or retarded cooling, or may be passed directly by gravity into the secondary kiln, where it may either be cooled gradually at a controlled rate or may be heat-treated. The secondary kiln is stated to be the first to be built especially to permit cooling or heat treatment under oxidising

or reducing conditions, which have been found to influence the formation of the various clinker compounds. The kilns are lined with high-alumina brick 4½ in. thick.

Each kiln (Fig. 1) is mounted on a welded steel frame pivoted at one end, and can be raised or lowered at the other end by means of screw jacks to change its inclination from horizontal to a slope of 1 in 12. Depending upon the inclination and speed of rotation of the kiln, the time of passage of the clinker may be varied from a few minutes to two or three hours. A speed range of 0·6 to 12 revolutions per minute is provided through a direct-drive unit comprising a two-speed 3 h.p. motor operating through a variable-speed drive (with a range of 10 to 1), which engages a ring gear on the kiln.

The kilns are fired with either oil or gas, with directional control of the flame. Temperatures, which may range up to 3,000 deg. F., are measured by an optical pyrometer mounted on a graduated quadrant, and which permits temperatures to be observed at any point along the kiln. To measure accurately the temperature of the clinker (eliminating the effect of the flame), provision is made for momentarily cutting off the fuel supply and preventing the escape of gases from the kiln while observation is made with the optical pyrometer.

The kiln draught is controlled to any desired degree by an automatic furnace-pressure controller which operates a butterfly damper in the stack ; this apparatus will compensate for sudden changes in operating conditions within a few seconds. The draught may also be altered manually by auxiliary push-button control ; its amount is measured by an inclined draught gauge.

Provision is made for flue-gas analysis by the Orsat apparatus. In addition, a chromel-alumel thermocouple is installed at the discharge end of each kiln, and a companion thermocouple is installed in the stack at a point 15 ft. above the base. The relative difference in temperature between these two points at a given time indicates whether the atmosphere is oxidising or reducing. By observation of thermocouple temperature the percentage of combustible gases may be quickly determined without the use of the Orsat apparatus. By means of chromel-alumel thermocouples temperature measurements are made of all discharged clinker, thus determining the cooling gradient after discharge is completed. Raw materials are ordinarily fed in the form of slurry, continuously agitated by compressed air.

Grinding Mills.

The grinding equipment consists of a three-stage continuous mill with a discharge capacity of 30 lb. of normal Portland cement per hour and a 30 in. by 3 ft. closed batch mill for which the usual charge of material is 125 lb. The mills were designed and built at the laboratory, and are employed both to grind raw materials and clinker. Comparative grinding costs can be determined based on power consumption measured by watt-hour meters connected to the driving motors.

The units of the continuous mill are mounted one above another (Fig. 2), each resting on two pairs of rollers which run in flanged tracks encircling the ends of

the shell. A tight-fitting door, extending flush with the inside of the shell, provides for changing the ball charge to suit grinding conditions. In the discharge head are $\frac{1}{8}$ in. by 2 in. slots through which the ground material is released. Lifting vanes attached to the outside of this head then pick up the material and drop it into a discharge tube.

To control the temperature of grinding, each unit is equipped with a removable insulating hood and gas heater. Temperatures up to 400 deg. F. may be attained, and the temperature of each unit is maintained within 10 deg. of the desired heat, which ordinarily corresponds to that obtaining in a commercial mill. Cooling may be accomplished by forcing air through the same system of hoods. Tem-

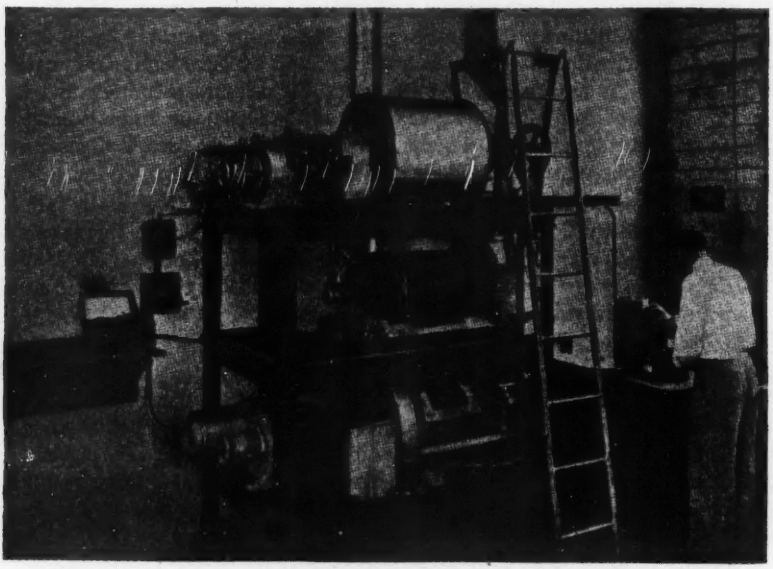

Fig. 2.

peratures are measured by a copper-constantan thermocouple on the delivery side of the slotted discharge head of each unit.

The primary unit of the continuous mill is $15\frac{1}{2}$ in. in diameter and $15\frac{1}{4}$ in. long. It is driven by a $\frac{3}{4}$ h.p. electric with a self-contained variable-speed drive which engages a ring gear on the shell. The speed range is 22 to 66 revolutions per minute. The secondary and finishing units are $13\frac{1}{2}$ in. in diameter and $19\frac{3}{4}$ in. long. They are driven by a $1\frac{1}{2}$ h.p. motor with a self-contained variable-speed drive that engages a ring gear on the shell of the finishing unit and drives the secondary unit by a roller chain operating on a sprocket on the unit shaft. The speed range is 22 to 66 revolutions per minute.

The clinker or other material is pre-ground in the batch mill or crushed to pass the No. 8 sieve, and then placed in the feed hopper of the primary unit. From the feed hopper the material passes on to a variable-speed rotating feed table from which it is removed at a controlled rate by an adjustable scraper. The material is then conveyed into the primary unit by means of a helical screw mounted on the shaft of the unit. Material discharged from either the primary or the secondary unit passes into a hopper from which a similar helical screw

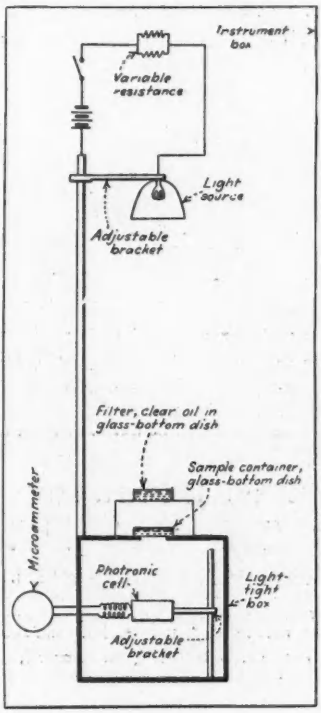

Fig. 3.

feeds it into the next unit. Samples may be taken from the hoppers through portholes. As ordinarily operated, the three units increase the fineness (specific surface) by approximately equal amounts.

Control of Grinding.

The fineness of ground cement is determined accurately by a new type of apparatus, called the suspension turbidimeter, which was developed in this laboratory. Rather than by the percentage passing a given sieve, fineness is expressed in terms of the specific surface, or surface area of particles in square centimetres per gram. The finer the cement the greater the specific surface.

It has been determined that the reduction in intensity of a light beam as it passes through a suspension of particles is dependent upon the surface area of the particles; hence the method employed is to measure, for a given concentration of the cement in a suitable suspending medium, the intensity of transmitted light from a fixed source as compared with the intensity of light transmitted through the clear medium alone. The apparatus (Fig. 3) consists of a light source producing a beam of parallel rays, a heat filter, a sample container, and a light-tight box containing a photronic cell connected to the terminals of a microammeter. Clear castor oil is used as the suspending medium. The use of the apparatus is independent of room temperature or of temperature and viscosity of the suspending medium, and in principle does not depend upon the use of Stokes's law, which involves the gravitational velocity of particles.

Results can be closely reproduced by men of average technical ability. Determinations of fineness are made quickly and at low cost. The method has been used in the control of grinding the final compositions of cement in the Boulder Dam cement investigations, and is in use by several producers of Portland cement. When a determination of particle-size distribution is desired, use is made of a "sedimentation turbidimeter" of the type that is employed in the determination of fineness of cements for Boulder Dam.

The research is under the general direction of Mr. Raymond E. Davis, director of the engineering materials laboratory. Mr. R. W. Carlson is assistant director in charge of research.

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Extensions and Improvements to the D'Origny-Sainte Benoite (Aisne) Cement Works.

THIS factory is regarded as a model cement works by reason of the general arrangement and equipment and the orderly manner of operation. The following notes translated from an article in "Revue des Matérieaux de Construction et de Traveaux Publics," by Mons. J. Prouteau, describe the recent improvements and additions to the bagging and despatch departments of the plant:

The factory may be regarded as consisting of two self-contained works, which will be designated Works A and Works B. The latter is built parallel to the Sambre and Oise Canal.

Works B possesses two bagging plants, one adjacent to the railway, in which the filling platform is at wagon level, and the other, for water transport, in a building alongside the canal with the sack store at ground level (Figs. 1 and 2). The first bagging plant comprises five two-unit Avery bagging machines with one three-nozzle Haver machine in reserve (Fig. 3). The second plant consists of seven two-unit "Libra" machines on a platform on the quay, from which the sacks fall directly into the boat via four chutes mounted on movable carriages; the inclination of these chutes is regulated by a hand winch. This plant also contains one two-nozzle Haver machine on the ground floor. The Libra and Haver machines are fed by a horizontal screw-conveyor, supported by a gangway connecting the silos of Works B with the filling plant. The feed-screw passes over the railway, and is fed by vertical elevators near the silos.

The bagging plant of Works A (Figs. 4-8) is one of the biggest and most modern in Europe. In designing it several difficult problems had to be overcome. For example, it was necessary to arrange for the packing of four different kinds of cement, to fill the silos from different sources, and to despatch the material by rail or water. The installation fulfils these requirements, and with a reduced personnel can deal with 140 to 150 tons of cement per hour, an output equal to that of the filling plant of Works B.

The plant at Works A consists of four reinforced concrete silos with a total capacity of 3,700 tons. The axes of the silos are in the same vertical plane and the two inner silos have conical bases. The introduction of valve-sack bagging machines necessitated modification of the method of discharging the silos. To this end a reinforced concrete platform was erected at a convenient height, forming the base of the silos. Two simple variable-speed screw-extractors of 13.75 in. diameter were fitted below this platform so as to ensure a regular extraction of cement, the lower part of the conical wall of the silos being pierced for the screws. The two cylindrical silos rest on pillars and readily allow the screws to be inserted.

These eight extractors (two per silo) supply four bucket-elevators (one to each silo) the delivery ends of which terminate each in two chutes. By means of these, either the screen belonging to the particular elevator, or, through a rever-

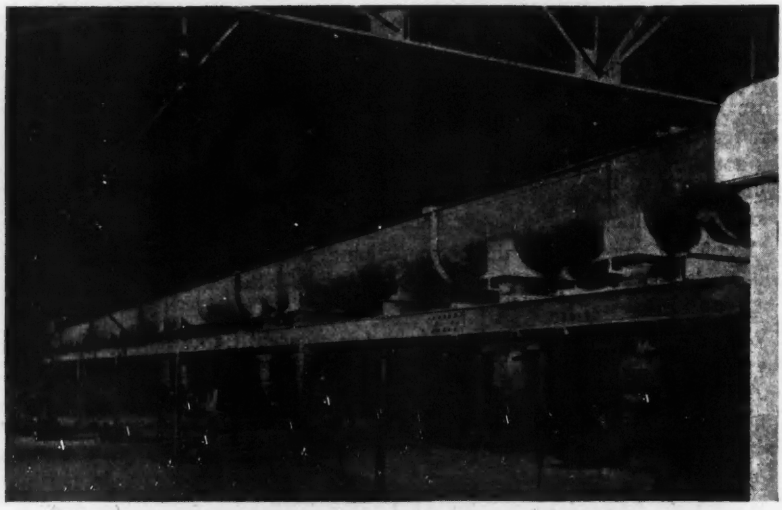

Fig. 1.—Bagging department for rail transport.

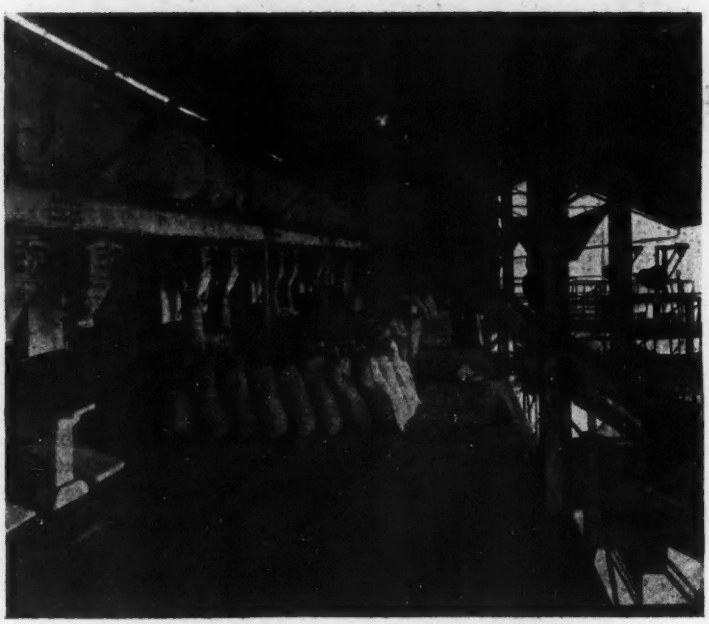

Fig. 2.—Bagging department for water transport.

sible collecting screw, any one of the other three screens can be fed. After screening the cement is deposited in a charging hopper above the bagging machine. There is thus a filling machine to each silo. Normally this packs cement from its own silo, but by means of the combination of screws and elevators it is possible for any machine to pack cement from any one of the four silos.

The packing plant of Works A is equipped with four three-nozzle Haver bagging machines. A summary of the chief points of a group of these machines

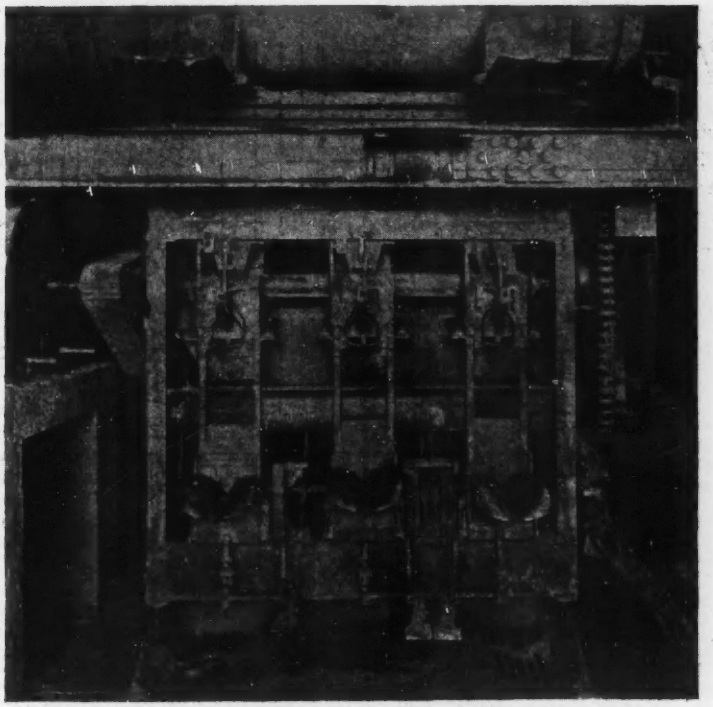

Fig. 3.—Three-nozzle Haver machine.

will first be given, followed by a detailed explanation of the working of a single machine. Such a group of machines consists of (1) feed apparatus; (2) screening plant; (3) reserve storage silo; (4) bagging machine; (5) arrangements for removing the sacks. In addition there are various accessories, such as the indicator showing the level of cement in the feed hopper, the cut-off, and the dust-extraction plant.

Each group of bagging machines is fed by a bucket elevator of a capacity of forty tons per hour. This delivers to a screen consisting of a 15.75-in.

diameter screw enclosed in a sheet-metal screen perforated with holes of 0.2 in. diameter; the sheet metal is fixed to the screw and turns with it. The cement passing through the screen falls into the bagging machine feed hopper. Foreign materials, particularly spent grinding media, are trapped by the screen, pass along the length of the metal sheet, and are rejected at the end. The feed hopper is of sheet iron and of ten tons capacity. It provides a regular supply of cement to the machine and neutralises irregularities in the discharge from the silo. At Origny all these feed hoppers are fitted with an appliance to indicate the level

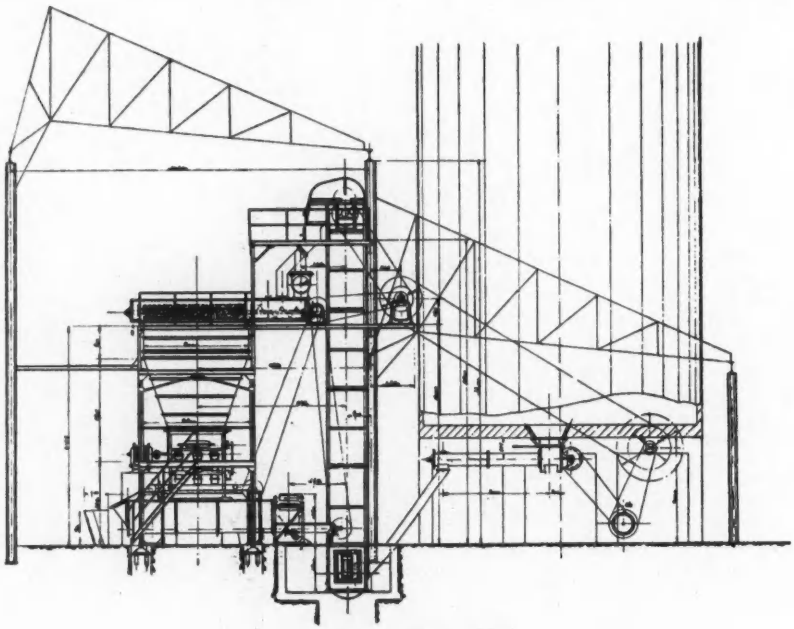

Fig. 4.—Transverse section.

of the material within them. The bagging machines are immediately beneath the feed hoppers.

The three-nozzle Haver bagging machine can be operated by one man; a single machine is capable of filling 650 to 700 110-lb. sacks per hour without fatiguing the attendant. Indeed, the latter has hardly any manual labour to do. With the Haver machine the operator, seated opposite the middle nozzle, has merely to pick up empty sacks and attach them to the filling nozzles. The filling mechanism is started by a pedal, and the filled sacks are disengaged by a light pressure of the heel on another pedal. One filled sack passes to the right, the second to the left, and the third between his legs, without the operator having to lift them.

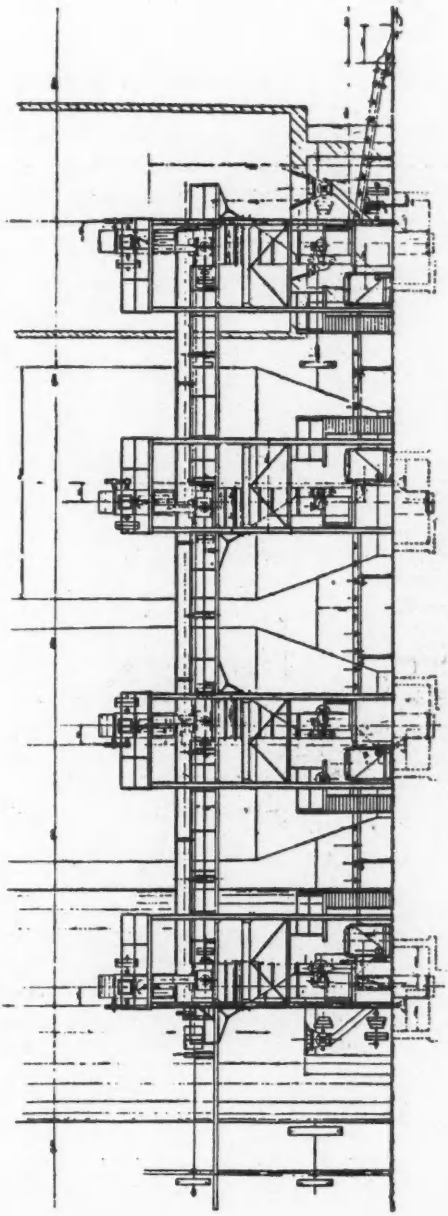

Fig. 5.—Haver machines with fixed hoppers.

The Haver automatic valve-sack bagging machine consists essentially of (1) the filling device, (2) weighing machine, (3) regulating mechanism, and (4) accessory appliances.

Fig. 6.—Packing plant at works "A."

The filling device consists of a cast-iron cylinder in which steel paddle blades rotate at 1,000 to 1,200 revolutions per minute. The cement reaches this cylinder regularly from above through the action of a mixing paddle, and is then thrown

by the paddle blades into the filling nozzle on to which the sack is fixed. The bottom of the sack rests on a stand of adjustable height. Cement is projected into the filling nozzle with considerable speed; sacks are filled at the rate of 11 to 13 lb. per second, so that a 110-lb. sack is filled in less than ten seconds.

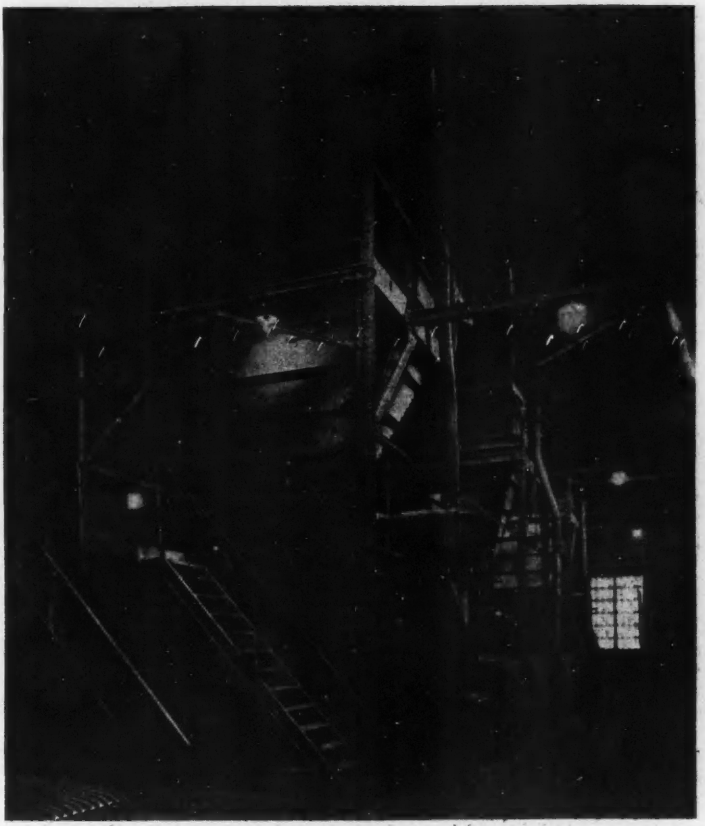

Fig. 7.—Packing plant at works "B."

The weighing machine consists of a beam with equal arms. Although it is of robust construction it is very sensitive and can weigh to one two-thousandth part of the amount to be weighed. One end of the beam carries the nozzle, sack suspension, and sack; the other carries a tare and a 110-lb. weight. The cut-off mechanism operates by displacing the nozzle and works in relation to the discharge from the projection turbine. It is outside the scope of this article to give details of the filling and regulating mechanism, but it may be pointed out that

the last few pounds in each sack are filled at a slower rate, and a compensating device annuls the error due to the time required for closing the sack feed-valve mechanism.

The accessories of the machine are the pedal mechanism for operating the weighing machine and for rejecting filled sacks. In addition there is a dust-collecting arrangement and dust-extraction screws. All shafts are mounted on dust-proof ball bearings, and are readily accessible. The machine, with all accessories, is driven by a 15-h.p. motor of the totally enclosed type; the motor control is conveniently near the attendant.

Fig. 8.—Conveyors, elevators, and filters on upper platform at works "A."

Dust is extracted from the bagging machine as follows (Fig. 8). Two dust conduits behind the machine are connected by piping to a 3½-h.p. motor-driven extraction fan placed on an upper platform. The fan sets up suction inside the machine and so withdraws floating dust, which is collected in filters on the upper platform. The filter consists of a sheet-metal rectangular conduit pierced with a number of cylindrical apertures of 16-in. diameter. Cloth bags 13 ft. long are fixed to these apertures, into which the dust-laden air withdrawn by the fan is discharged. The dust is retained in these bags, which are removed and cleaned from time to time.

A device enables the attendant to tell at a glance the quantity of cement in the feed hopper. This indicator was devised by the Kohlenscheidung Gesellschaft

(K.S.G.), of Berlin. It consists in principle of a cylindrical sheet-metal contact box closed by a flexible diaphragm. This membrane is deflected by the pressure of the cement, and makes contact with a carbon plate, thus closing an electrical circuit operated at 14 volts. Two of these contact boxes are freely suspended from the overhead cover of the feed hopper by tubes through which pass electrical connections leading to a panel fitted with two lamps, red coupled to the upper box and green to the lower. When the hopper is empty neither lamp glows; as it is filled the green lamp first lights up, and then the red lamp when it is full. The attendant should disconnect the feed to the hopper when the red lamp lights up, although in practice he may instead increase the rate of sack filling for some minutes. This indicator has been used at Origny for eighteen months and has given every satisfaction. In certain cases three indicator boxes with three warning lights have been fitted to the hopper, as in Fig. 9, giving an intermediate indication of the height of the material; this third indicator has not proved to be essential.

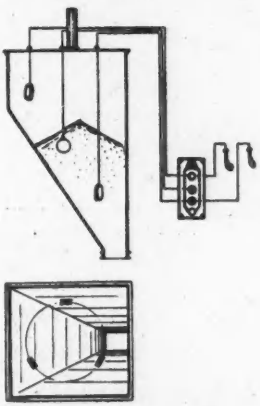

Fig. 9.—Level indicator.

On leaving the bagging machines the filled sacks fall on to a 31-in. reversible rubber-belt conveyor beneath the platform on which the machine attendant is seated. Sacks are conveyed either (*a*) to the loading platform, whence they are taken by hand truck to railway wagons, or (*b*) to a 20-in. rubber-belt conveyor running horizontally along the length of the building between the bagging machines and the silos; this is used for sacks to be despatched by water. This last conveyor is driven by a chain from a bevel gearbox, supplied with power through reduction gearing from a 5-h.p. motor running at 1,405 revolutions per minute. This motor also drives a steel-band conveyor running underground, to which sacks from the 20-in. conveyor are directed by a metal chute (Fig. 10). This steel conveyor runs beneath the railway adjoining the packing plant of Works A, and emerges at a height of 10 ft. in a storage shed 100 ft. long alongside the canal.

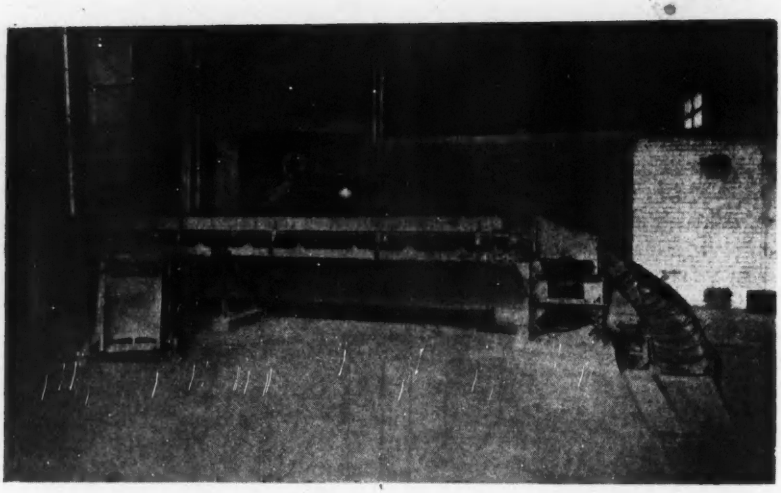

Fig. 10.—Longitudinal collecting conveyor for water transport, terminating in a metal chute.

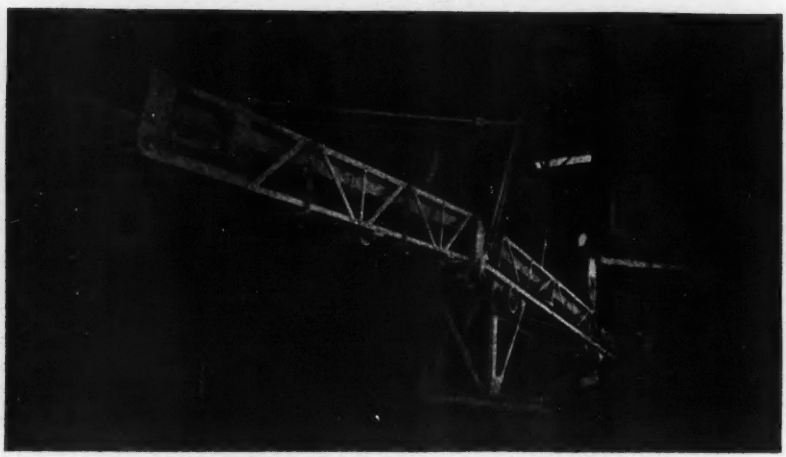

Fig. 11.—Movable conveyor at works "A."

In order that the loading of boats may be carried out under cover without moving the boat, the conveyors used are movable and adjustable, and deliver directly into the vessel. The arrangement is as follows: At the point where the inclined conveyor leading from the filling machines ends, the sacks are received in a deflecting chute by which they are guided to one of two almost horizontal 31-in. rubber-belt conveyors running along the wall of the building. These conveyors are driven by reduction gearing from a 3½-h.p. motor running at 1,430 revolutions per minute, and are fitted with short curved chutes down which the sacks fall on to movable articulated conveyors. These last consist of two articulated arms, the inclination of one of which can be varied, while this arm can also be swung round on a pivot in a semicircle of 12 ft. radius. The working length of the belt is about 17 ft., and the conveyor is driven by its own 2½-h.p. motor running at 1,400 revolutions per minute. The inclination of the adjustable arm is regulated by hand by a system of cables and pulleys.

More and more of the output of the works is being despatched in motor-driven vessels with steel hulls. Risk of damage by water is thus reduced to a minimum. Handling is greatly facilitated by the disposition of the hold, which runs from one end of the vessel to the other without partitions, the cabin and controls being at the stern. These vessels are 126 ft. long with 16½ ft. beam, and have a carrying capacity of 250 tons. They are driven by heavy oil engines, and have a river speed of 4 to 5½ knots loaded and 6½ to 7 knots empty. The fleet consists of ten of these vessels, which are equipped with electric light.

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SPANISH.	FRENCH.	ENGLISH.	GERMAN.
abacá	manille	manilla	Manilahanf
abertura	orifice	opening	Oeffnung
acanaladura	gorge	groove	Rille, Verengung, Kehle
accionamiento por muñón central	commande par le tourillon	central drive	Zentralantrieb
aceite	huile	oil	Oel
acero	acier	steel	Stahl
acero al carbono	acier au carbone	carbon steel	Kohlenstoffstahl
acero al crisol	acier au creuset	crucible steel	Tiegelstahl
acero dulce	acier doux	mild steel	Schmiedestahl
acero inoxidable	acier inoxydable	stainless steel	rostfreier Stahl
ácido clorhídrico	acide chlorhydrique	hydrochloric acid	Salzsäure
ácido fluorhídrico	acide fluorhydrique	hydrofluoric acid	Flussäure
ácido graso	acide gras	fatty acid	Fettsäure
ácido nítrico	acide nitrique	nitric acid	Salpetersäure
ácido sulfúrico	acide sulfurique	sulphuric acid	Schwefelsäure
acodadura, inflexión	rupture	break	Knick, Riss
acoplamiento elástico	joint élastique	flexible coupling	Gelenkkupplung
adherencia	adhérence	adhesion	Haftfestigkeit
adherencia al revestemiento	collage au garnissage	adherence	Anbacken, das
agitación por aire	agitation par l'air	air agitation	Luftrührung
agitador	agitateur	stirrer	Rührwerk
agotar, extraer	faire le vide	exhaust, to	entleeren, ausschöpfm
agua	eau	water	Wasser
agua de amasado	eau de gâchage	mixing water	Anmachewasser
agua del mar	eau de mer	sea water	Seewasser
agua ordinaria	eau potable	tap water	Trinkwasser
aguja	aiguille	needle	Nadel
aguja de Vicat	aiguille de Vicat	Vicat needle	Vicatnadel
agujero	ouverture	hole	Loch, Oeffnung
aire comprimido	air comprimé	compressed air	Druckluft
aire húmedo	air humide	damp atmosphere	feuchte Luft
aislador	isolateur	insulator	Isolator
alambre	fil	wire	Draht
alargamiento	allongement	elongation	Dehnung
aleación	alliage	alloy	Legierung
aleta de turbina	ailette de turbine	turbine blade	Turbinenflügel
algodón	coton	cotton	Baumwolle
alimentación	alimentation	feed	Zufuhr
alimentación de carbón	alimentation en charbon	coal feed	Kohlenzufuhr
alimentador de cuchara	cuiller d'alimentation	spoon-fed	Löffelzufuhr
alimentación por surtidores	enfournement par pulvérisation	spray feed	Sprühaufgabe
almacén	entrepôt	store / warehouse	Vorratslager / Lagerhaus
alto horno	haut fourneau	blast furnace	Hochofen
alúmina	alumine	alumina	Tonerde
amasar	gâcher	gauge, to	anmachen
amorfo	amorphe	amorphous	amorph
análisis gravimétrico	analyse gravimétrique	gravimetric analysis	Gewichtsanalyse
análisis por levigación	analyse par sédimentation	elutriation analysis	Schlämmanalyse
ancho	large, largeur	wide	breit

A

SPANISH.	FRENCH.	ENGLISH.	GERMAN.
anemómetro	anémomètre	anemometer	Windmesser
anhídrido carbónico	acide carbonique	carbonic acid	Kohlensäure
anillo adherente de pasta	anneau de boue collé au cylindre	slurry ring	Schlammringansatz
anillo de clinker	anneau de clinker	clinker ring	Klinkerring
anillo de hierro angular	cercle en cornière	angle ring	Winkelring
anillo de rodadura	anneau de roulement	riding ring	Laufring
anillo o aro de goma endurecida	bague en ébonite, bague en caoutchouc durci	vulcanite ring	Hartgummiring
antracita	anthracite	anthracite coal	Anthrazitkohle
apagar	éteindre (la chaux)	slake, to	löschen
aparato de ensayo	machine à essayer	testing machine	Prüfmaschine
aplicación	usage	use	Verbrauch
apoyo	support	support	Lager (Kugel- etc.)
arcilla	argile	clay	Ton
arcilloso	argileux	argillaceous	tonhaltig
arder	cuire	to burn	brenen
arena	sable	sand	Sand
arena normal	sable normal	standard sand	Normalsand
arrancador	démarreur	starter	Anlasser
artesa	auget	trough	Rinne, Trog
asentar por sacudidas	tasser per secousses	shaking (to compact)	einrütteln
aspiración	aspiration	suction	Saug (zug)
aumentar	augmenter	increase, to	steigern, vermehren
aumento	grossissement	magnification	Vergrösserung
azufre	soufre	sulphur	Schwefel

B

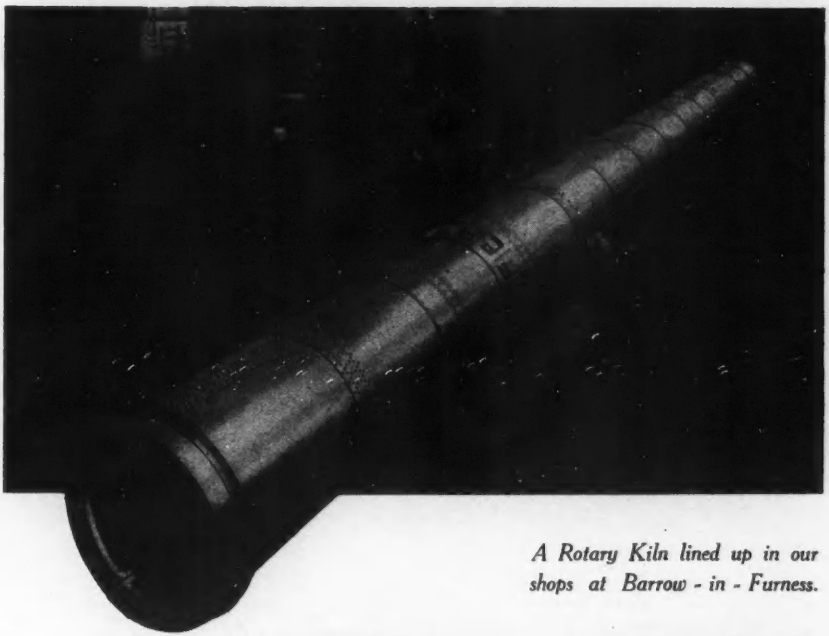
balance térmico	bilan thermique	heat balance	Wärmebilan
barrena montada en martillos de aire comprimido	perforatrice à percussion fonctionnant à l'air comprimé	jackhammer air drill	Luftbohrhammer
barril	baril	barrel	Fass
barril de madera	baril en bois	wooden keg	Holzfass
barro	boue, vase	mud	Lehm
báscula-puente	pont à bascule	weighbridge	Brückenwaage
básico	basique	basic	basisch
bastidor	cadre	frame	Rahmen
birrefringencia	double réfraction	double refracting	doppelbrechend
bola molturadora	boulet pour broyeur	grinding ball	Mahlkugel
bomba	pompe	pump	Pumpe
bomba de émbolo zambullidor	pompe à piston plongeur	plunger pump	Plungerpumpe
bomba de tres tiempos	pompe à 3 pistons	three throw pump	——
bombar	pomper	pump, to	pumpen
boquilla	bec / tuyère	jet / nozzle	Düse
briqueta	brique	briquette	Ziegel
bronce	bronze	gun metal	Geschützmetall
bureta	burette	burette	Bürette

C

caballo de vapor	cheval-vapeur	horse power	Pferdekraft
cabrestante	treuil	winch	Winde
cadena	chaîne	chain	Kette
cal	chaux	lime	Kalk
calcáreo	calcaire	calcareous	kalkhaltig
caldera	chaudière	boiler	Kessel
caldera de recuperación de calor	chaudière à chaleurs perdues	waste heat boiler	Abhitzekessel

C

SPANISH.	FRENCH.	ENGLISH.	GERMAN.
caldera de tubos de agua	chaudière aquatubulaire	water tube boiler	Wasserrohrkessel
caldera de tubos de humo	chaudière à tubes de fumée	flame tube boiler	Flammrohrkessel
cal grasa	chaux grasse	common lime	Luftkalk
cal hidráulica	chaux hydraulique	hydraulic lime	Wasserkalk
calibrar	graduer, classer	calibrate, to	kalibrieren
calidad	qualité	quality	Güte
caliza	calcaire, pierre à chaux	limestone	Kalkstein
calor	chaleur	heat	Wärme
calor de disolución	chaleur de dissolution	heat of solution	Lösungswärme
calor específico	chaleur spécifique	specific heat	spezifische Wärme
calor perdido	chaleur perdue	waste heat	Abhitze
cámara de ladrillo	maçonnerie	brickwork	Ziegelmauerwerk
cambio de volumen	changement de volume	volume change	Volumenänderung
cangilón	godet	bucket	Becher
cantera	carrière / fosse	quarry / pit	Steinbruch / Grube
capacidad de ruptura	capacité de rupture	rupturing capacity	Schaltfähigkeit
caperuza del horno	coiffe du four	kiln hood	Ofenkopf, Ofenhaube
carbonera	soute	bunker	Bunker
carbón semi-graso	houille, demi-grasse	gas coal	Gaskohle
carbón tipo	charbon normal	standard coal	Normalkohle
carga	charge	load	Belastung
carril	rail	rail	Schiene
castrillo	herse, râble	harrow	Egge
caucho	caoutchouc	rubber	Gummi
cemento aluminoso	ciment alumineux	aluminous cement	Tonerdezement
cemento de altos hornos	ciment de laitier	blast-furnace cement	Hochofenzement
cemento de endurecimiento rápido	ciment à durcissement rapide; ciment spécial	rapid hardening cement	hochwertiger Zement
ceniza	cendre	ash	Asche
ceniza del carbón	cendre de charbon	coal ash	Kohlenasche
centímetro cúbico	centimètre cube	cubic centimetre	Kubikzentimeter
central de energía; central eléctrica	station génératrice; station d'énergie	generating station / power station	Kraftstation
central de fuerza	installation de force motrice	power plant	Kraftanlage
cerrado	enfermé	enclosed	gekapselt
ciclón	cyclone	cyclone	Zyklon
cilindro	cylindre	cylinder	Zylinder
clavo	clou	nail	Nagel
cocción insuficiente	incuit	insufficiently burnt	Schwachbrand
cocer	cuire	burn, to	brennen
coeficiente de dilatación térmica	coefficient de dilatation thermique	coefficient of thermal expansion	Wärmeausdehnungskoeffizient
cojinete de manguito	palier lisse	sleeve bearing	Muffenlager
cojinete ordinario	palier lisse	plain bearing	Gleitlager
cojinete o soporte	chaise	pedestal	Lager, Lagerrahmen
combustible	combustible	fuel	Brennstoff
combustion	combustion	combustion	Verbrennung
composición	composition	composition	Zusammensetzung
compuerta de descarga	sas de vidange	discharge lock	Entleerungsschleuse
compuesto	substance	compound	Bestandteil
conductividad	conductibilité	conductivity	Leitfähigkeit
conducto	carneau	flue	Fuchs (Ofen)
conducto de protección	échafaudage, ossature	gantry	Gangbrücke



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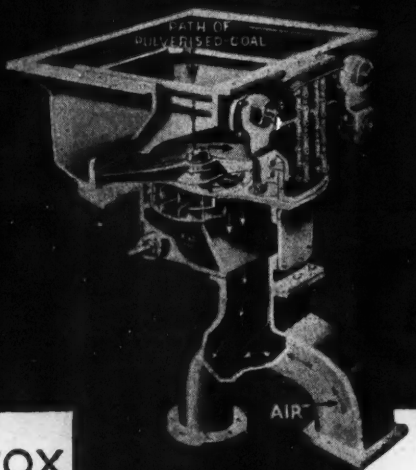

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C

SPANISH.	FRENCH.	ENGLISH.	GERMAN.
conmutador	commutateur	commutator switch	Umschalter Schalter
conservación alternada	conservation alternative	alternating curing	Wechsellagerung
conservar	garder	cure, to	lagern
conservación combinada	conservation combinée	combined storage	kombinierte Lagerung
consistencia de tierra húmeda	consistance de la terre humide	earth moist	erdfeucht
consistencia normal	consistance normale	normal consistency	Normalsteife
constancia o estabilidad de volumen	invariabilité, stabilité de volume constance de volume	soundness volume constancy	Raumbeständigkeit
consumo de energía	consommation d'énergie	power consumption	Kraftverbrauch
contador	compteur	counter	Zählvorrichtung
contracorriente	contre-courant	counter-flow	Gegenstrom
contraerse	se contracter	contract, to shrink, to	schwinden
controller de tipo de tambor	contrôleur du type à tambour	drum type controller	Walzenumschalter
corona dentada	jante à denture droite	spur rim	Zahnkranz
corriente alterna	courant alternatif	alternating current	Wechselstrom
corriente continua	courant continu	continuous current	Gleichstrom
corriente trifásica	courant triphasé	three phase current	Dreiphasenstrom
coste de funcionamiento	dépenses d'exploitation	operating costs	Betriebskosten

(To be continued.)

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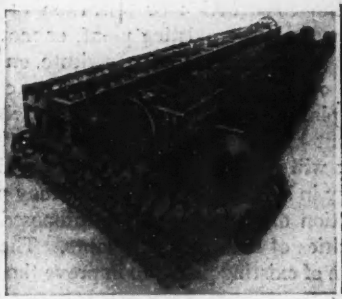

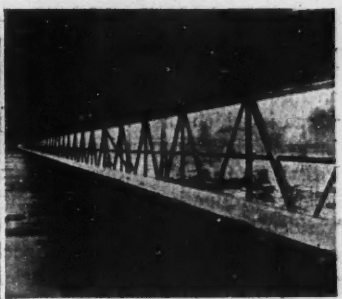

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REPLACEMENTS AND SPARES A SPECIALITY.
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United States "Code" for the Cement Industry.

THE "Code of Fair Competition" for the cement industry in the United States has been signed by President Roosevelt, and is now law. It contains the following regulations:

WAGES AND HOURS OF LABOUR.—Hours of employment are permitted to be flexible over any half calendar year but are not permitted to exceed an average of more than 36 hours per week during this period nor more than eight hours a day. Maximum hours of work are limited to 42 a week for employees other than clerical and office employees, who are limited to 40 hours. Employees in packing and despatch departments are limited to 10 hours a day and 36 hours a week averaged over any half calendar year. Employees engaged in executive, administrative, technical, sales, staff and emergency work are exempt from maximum hours.

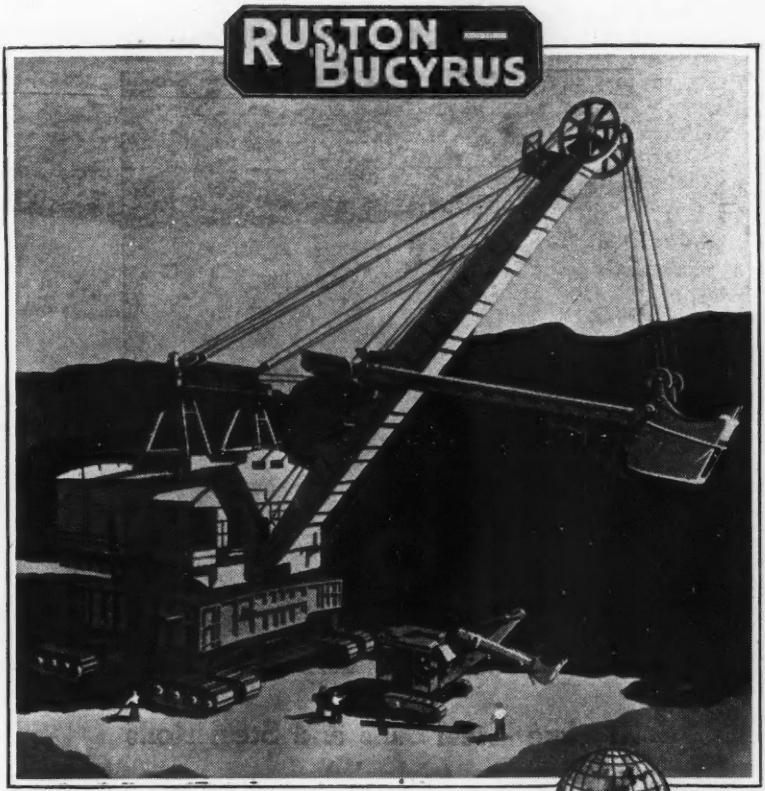
Minimum wages are established in twelve geographical districts and range from a minimum hourly rate of 30 cents to a minimum of 40 cents.

Comparison of the production of Portland cement in the years 1928 and 1932 shows a decline of 54 per cent. Comparison of number of persons employed by the industry shows a decrease from 34,244 in 1928 to 11,941 in February, 1933, or 68.8 per cent. It is estimated that, based on employment in 1932, the adoption of the average 36-hour week will result in the absorption by the industry of 5,618 additional workers and increase wages by approximately 40 per cent.

SHARING AVAILABLE BUSINESS.—The Board responsible for operating the Code is authorised to formulate plans for the equitable allocation of available business among all members of the industry or among members of the industry operating in one or more districts, and for the control of cement stocks. Each member of the industry is to receive notice of such plan and to participate in any meeting of the industry at which any such plan is being considered.

PRODUCTIVE CAPACITY.—Prior to the construction or operation of a new plant, or increase in the productive capacity of an existing plant, or moving all or part of such a plant from one place to another, the Cement Institute, on receipt of such information, shall collect data concerning existing productive capacity in the area in which the proposed new plant is to be located, together with data pertaining to the consumption of cement in that area. If the information collected discloses that the proposed plant will result in further increasing the problem of over-production or over-capacity in such area, the Institute may petition the President to prohibit the construction or operation of the proposed plant, or the increase in manufacturing capacities of such existing plants. These provisions do not prevent the modernisation of existing plants to improve the quality of the product and/or operating efficiency.

SELLING PRICES.—Under the Code it is an unfair method of competition for any member of the industry to sell or offer to sell cement at less than his expenses of manufacture, provided, however, that any member of the industry may sell or offer to sell cement at a price below his own expenses for the purpose of meeting the competition of any other member of the industry whose price is not less than the expenses of manufacturing of such other member.



From a Photograph

1934 DIAMOND JUBILEE YEAR

Sixty years ago Rustons built their first "steam navvy" and fifty-two years ago Bucyrus built theirs. Leaders in the Eastern and Western hemispheres respectively, these two oldest excavator manufacturers enjoyed tremendous success.

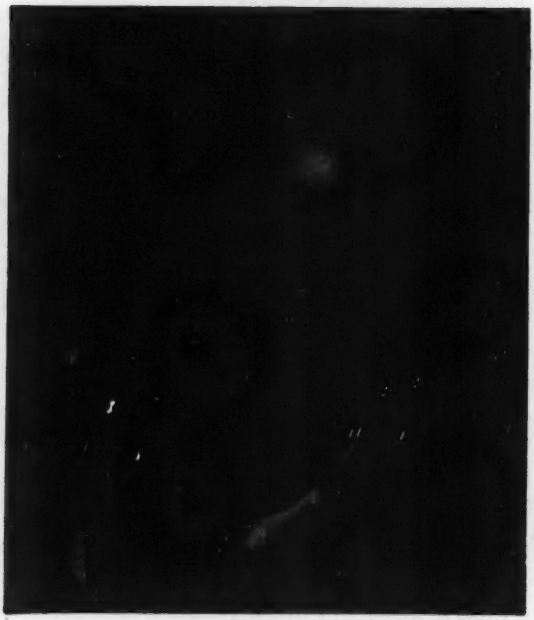
In 1930, Rustons joined forces with the Bucyrus Co., forming Ruston-Bucyrus Ltd., and pooling their valuable experience gained from the designing, manufacturing, and successful installation of thousands of excavators at work throughout the world.

To-day, the Ruston-Bucyrus range of excavating machinery is outstanding, upholding the traditional supremacy of 60 years.

60 YEARS OF PROGRESS

RUSTON-BUCYRUS LTD

EXCAVATOR WORKS LINCOLN ENGLAND



Klöckner-Steel Balls and Steel Rolls (Cylpebs),

made of special steels with great natural hardness as, e.g., special open-hearth steel, chromium steel, chromium-molybdenum steel, silicon steel and manganese steel.

Klöckner-Werke A.-G.

Georgs-Marien-Hütte, Osnabrück, Germany.

Air Separation.

INTERESTING details of an air-swept coal grinding tube mill in operation at the modern steam-power plant of the Ube Cement Co., Ltd., is given by Mr. Kanichi Nakayasu in a paper read before the annual meeting of the Association of Japanese Portland Cement Engineers held in Tokio in October, 1932.

The coal mill is a Humboldt high efficiency tube mill with stationary air separator, 1.85 m. diameter by 2.75 m. long, requiring 95 h.p., and running at a speed of 25 revolutions per minute. The normal capacity is 3.5 tons per hour; the specified fineness is 75 per cent. through a 200-mesh sieve, and the moisture of the coal is 15 per cent. maximum with preheated air of 300 deg. C.

The boilers are a Mitsubishi 560 sq. m. vertical watertube boiler with water-cooled combustion chamber, and a Takuma 556 sq. m. watertube boiler with air-cooled combustion chamber lined with carborundum brick. Each boiler has two mills and four turbulent burners.

The coal used, known as Ube " OHA," has the following characteristics:

	Wet.	Dried.
Moisture	12.80 per cent.	0.00 per cent.
Volatile matter	28.78 ,,	33.00 ,,
Fixed carbon	21.50 ,,	24.00 ,,
Ash	30.88 ,,	42.30 ,,
Calorific value	3,517 cal. per kg.	4,033 cal. per kg.

The ash is non-caking, and has a softening temperature of 1,340 deg. C. and a melting temperature of 1,490 deg. C.

The following conclusions are drawn as a result of the operation of the plant.

The stationary air separator is in the best working condition when the return of coarse coal is 20 per cent. when 1.5 tons per hour are fed, 30 per cent. when 2.0 tons per hour are fed, and 36 per cent. when 3.0 tons per hour are fed.

The fineness and power consumption are given in Table I. The percentage of

TABLE I.

Capacity of mill in tons per hour.	Fineness per cent. residue on 4,900 sieve.	Total power kWh per ton coal.
1.5	19.0	60.0
2.0	27.0	26.0
2.5	35.0	17.0
3.0	42.0	14.0
3.5	45.0	13.0
4.0	42.0	12.0

power required for each machine is 69 per cent. for the mill, 22 per cent. for the coal injection fan, 8 per cent. for the forced draught fan, and 1 per cent. for the coal

feeder. In this mill the total power consumption per ton of coal, including miscellaneous accessories, is about 40 per cent. that of the ordinary tube mill with separate coal drier.

The turbulent burners in connection with the air-swept tube mill can shorten the flame to 4 metres, as the air for combustion and the pulverised coal are intimately mixed in the mill and connecting pipes. The length of the flame is easily controlled by regulating the primary and secondary air to the combustion chamber.

Explosion of pulverised coal in this installation can be easily prevented by controlling the temperature of the heated air according to the percentage of moisture in the raw coal, and by not reducing the amount of coal to less than one-fifth of the normal capacity.

The average life of the impeller of the coal injection fan, which is the main item requiring repair, is 1,400 operating hours. The coal consumption per kWh is 1.20 kg. of wet coal when the 10,000 kW Ljungström turbo-generator is developing power at half load.

Trade Notice.

New Excavator.—Messrs. Ruston-Bucyrus Ltd., of Lincoln, have introduced a ⅜-yard "Universal" excavator, which weighs only seven tons. This machine, known as the "10–RB," is available with shovel, dragline, drag-shovel, skimmer, grabbing crane, and crane equipments, and is recommended for all types of excavation work in quarries and construction work. The crane has a capacity of 2½ tons. The drive is by a 30–25 h.p. petrol-paraffin engine, and the machine is mounted on a caterpillar track. We are informed that six of these machines were sold within a week of their introduction at the British Industries Fair.

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